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THE ORBIT OF β *DELPHINI.*

By R. G. Aitken.

This investigation was undertaken to determine whether the observations of a close and difficult double star are sufficiently accurate to make it worth while to correct the elements of its approximate orbit by differential methods. Such methods have been applied in researches on the orbits of some of the moderately easy binary and ternary systems, as, for example, in Seeliger's classic memoirs on *Zeta Cancri.* But the orbits of the more difficult binaries have generally been based in part or wholly upon the graphic construction of the apparent ellipse, though the resulting elements have occasionally been improved by the use of Klinkerfues's very convenient method of six position-angles.

The system of β *Delphini* seemed well adapted for such an investigation. Though discovered by Burnham as recently as 1873, it has already completed a revolution. The maximum distance does not reach 0".7, and its minimum distance, about 0".2, does not fall below the resolving power of our larger telescopes. The pair has been, accordingly, well observed by all the leading double-star observers of the last quarter century, and a number of orbits have been computed. The two most recent ones, by See in 1895, and Burnham in 1898, are very similar in all their elements except the length of the semiaxis major.

The first step in the present investigation was to compare with these two orbits the observations of the star collected in Burnham's General Catalogue of his double stars. The comparison was made by drawing interpolating curves for the computed angles and distances derived from either orbit, and plotting the observed positions on the same scale. There seemed but little choice between the two curves for position-angles, See's representing the observed positions somewhat better at the two extremities, Burnham's those in the middle portion. But Burnham's distance-curve represents the distance-measures of the best observers far better than does See's.

Using See's elements as a basis, I next computed the following set of elements by KLINKERFUES's method of six position-angles:—

SYSTEM I.

$P = 27.94$ years
$T = 1883.230$
$e = 0.363$
$a = 0''.475$
$\Omega = 179^\circ.10$
$i = 61 .75$
$\lambda = 352 .80$

Interpolating curves were constructed from these elements, and the individual observations to 1902 compared with them, the measures having been taken from original sources. In this connection I wish to express my hearty thanks to Professor SCHIAPARELLI, who kindly sent me the full details of his fine series of measures of this pair.

Angle-measures that gave residuals exceeding 10° as the result of this comparison were rejected, unless the distance at the time of observation was as small as 0''.25. In this case the limit was set at 15°. Individual distance-measures were rejected only when they differed by 0''.2 from the computed, but an observer's mean result for any year was given weight zero if it differed by 0''.15 from the computed distances. The annual means were then formed by combining the measures of the various observers, assigning weights to each, depending in part upon the number of observations and in part upon the aperture of the telescope used.

When these annual means were compared* with the elements given above, it appeared that the distances were satisfactorily represented, but the residuals in angle seemed to show systematic deviations. The measures of each observer had already been examined for systematic errors of observation, but only two series of observations—SCHIAPARELLI's and BURNHAM's—were of sufficient extent to afford a basis for deriving reliable corrections for such errors, and their measures did not indicate appreciable errors of this kind.

A least-square solution therefore seemed unwarranted, and it was considered better to combine the annual means to form

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*The details of this comparison and of the comparison of BURNHAM's and SCHIAPARELLI's observed positions with those derived from Elements II are given in Lick Observatory *Bulletin* No. 26.

six normal position-angles and again apply KLINKERFUES'S method.

These normal angles, with dates and residuals, are as follows:—

DATE.	Mean Anomaly. System I.	$\Delta\theta$ (O–C) System I.	Normal Angle.	Weight.	$\Delta\theta$ (O–C) System II.
1876.246	270°	— 1°.26	22°.64	22	— 1°.58
1882.066	345	+ 2 .45	159 .45	11	+ 1 .49
1885.946	35	— 0 .88	220 .94	15	— 4 .37
1888.662	70	+ 2 .56	300 .86	30	+ 1 .18
18 .318	130	— 0 .60	341 .27	70	— 0 .47
1899.526	210	+ 1 .40	364 .33	77	+ 0 .93

The elements resulting from this new solution are:—

SYSTEM II.

$P = 27.66$ years
$T = 1883.10$
$e = 0.363$
$a = 0''.475$
$\Omega = 178^\circ.90$
$i = 60.90$
$\lambda = 351.95$

The value of *a* was derived from several normal values of the observed distances based upon measures by BURNHAM, BARNARD, SCHIAPARELLI, COMSTOCK, HUSSEY, and AITKEN.

The last column in the table shows that these new elements represent all the normal places, except the first and third, better than System I. These two places—and the second as well—have much less weight than the last three; and it is to be remembered that they are based in large part upon measures with small telescopes. Considering this fact and the small apparent separation of the components of *β Delphini* in those years, we should expect larger errors in the measures made before 1887 than in the later ones.

I therefore regard System II as satisfactory, so far as the representation of the data at hand is concerned, and I think that the use of differential formulæ and a least-square solution will be of little service in improving these elements until more extended series of measures are available.

As the apparent orbital motion of this pair will increase rapidly during the next few years, I append an ephemeris, giving the relative positions of the two components according to Elements II for every tenth degree of mean anomaly to the date of the next periastron passage.

EPHEMERIS.

DATE.	M.	θ	ρ
1903.077	260°	18°.6	0″.48
1903.845	270	23 .6	0 .43
1904.613	280	30 .1	0 .37
1905.382	290	38 .9	0 .31
1906.150	300	51 .8	0 .26
1906.918	310	71 .2	0 .21
1907.687	320	97 .8	0 .19
1908.455	330	125 .7	0 .20
1909.223	340	147 .3	0 .24
1909.992	350	162 .8	0 .28
1910.760	360	175 .0	0 .30

September 7, 1902.

PLANETARY PHENOMENA FOR NOVEMBER AND DECEMBER, 1902.

By MALCOLM MCNEILL.

NOVEMBER.

Mercury is a morning star throughout the month, coming to greatest west elongation on the morning of November 4th. It will then rise about an hour and a half before sunrise, and until about November 20th it will be above the horizon at least an hour before the Sun. The present west elongation is only 19° (less by 8° than the east elongation of September), due to the fact that the planet passed its perihelion on October 24th, only a week before the time of greatest elongation.

Venus has been morning star since February 14th, but now comes to superior conjunction, and becomes an evening star on November 28th. It is almost too near the Sun to be seen at any time during the month.

Mars rises not long after midnight, coming to the horizon about one minute earlier each night. It moves 15° eastward and southward through *Leo* into *Virgo*. No very bright stars are near its path, but toward the close of the month it is somewhat to the west of *β Virginis*. It is beginning to approach